

Claims

1. A method of generating a gas plasma characterised by the feature that the applied voltage exhibits a waveform which is truncated.
- 5 2. A method of generating a gas plasma characterised by the feature that the applied voltage exhibits a waveform which decays asymmetrically from its peak value.
3. A method of generating a gas plasma characterised by the feature that the applied voltage exhibits a waveform which is truncated and which decays asymmetrically from its peak value.
- 10 4. The method of any of the preceding claims wherein the applied voltage, V , as a function of time, t , said time t being measured from any arbitrary instant, takes the form of a waveform, $V(t)$, of cycle time T , wherein in at least one of the half cycles, i.e. between $(t=iT)$ and $(t=iT + T/2)$ or between $(t=iT + T/2)$ and $(t=(i+1)T)$, where i takes integer values, the waveform is characterised by the magnitude of the integral of the
15 voltage with respect to time being greater in the first half of said half cycle than in the second half of said half cycle.
5. The method of any of Claims 1 to 3 wherein the applied voltage, V , as a function of time, t , said time t being measured from any arbitrary instant, takes the form of a waveform, $V(t)$, of cycle time T , wherein in at least one of the half cycles, i.e. between
20 $(t=iT)$ and $(t=iT + T/2)$ or between $(t=iT + T/2)$ and $(t=(i+1)T)$, where i takes integer values, the waveform is characterised by a period of substantially constant voltage.
6. The method of Claim 5 wherein the applied voltage is defined by equation E1 herein.
7. The method of Claim 4 wherein the applied voltage is defined by equation E2 herein.
8. The method of Claim 4 wherein the applied voltage is defined by equation E3 herein.

9. The method of any of Claims 1 to 3 wherein the applied voltage is generated by the action of a control system, said control system using a measurement of the plasma discharge current as an input signal.

10. A method of generating a gas plasma substantially as described herein with
5 reference to and as illustrated in the accompanying drawings.

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT
(PCT Article 36 and Rule 70)

Applicant's or agent's file reference HMDAL/8718INT	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/PEA/416)	
International application No. PCT/GB 03/03485	International filing date (day/month/year) 07.08.2003	Priority date (day/month/year) 07.08.2002
International Patent Classification (IPC) or both national classification and IPC H05H1/46		
Applicant LOUGHBOROUGH UNIVERSITY ENTERPRISES LTD et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 8 sheets, including this cover sheet.
- ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).
- These annexes consist of a total of 3 sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the opinion
- II ☐ Priority
- III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☐ Certain defects in the international application
- VIII ☐ Certain observations on the international application

Date of submission of the demand 01.03.2004	Date of completion of this report 05.10.2004
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**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. **PCT/GB 03/03485**

I. Basis of the report

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*):

Description, Pages

1-29 as originally filed

Claims, Numbers

1-19 received on 07.09.2004 with letter of 07.09.2004

Drawings, Sheets

1-10 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

**INTERNATIONAL PRELIMINARY
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5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)).

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

☐ the entire international application,

☒ claims Nos. 19

because:

☐ the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination (specify):

☒ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. 19 are so unclear that no meaningful opinion could be formed (*specify*):

see separate sheet

☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.

☐ no international search report has been established for the said claims Nos.

2. A meaningful international preliminary examination cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

☐ the written form has not been furnished or does not comply with the Standard.

☐ the computer readable form has not been furnished or does not comply with the Standard.

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims	6-9,12
	No: Claims	1-5,10,11,13-18
Inventive step (IS)	Yes: Claims	6-9,12
	No: Claims	1-5,10,11,13-18
Industrial applicability (IA)	Yes: Claims	1-18
	No: Claims	-

2. Citations and explanations

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see separate sheet

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/GB 03/03485

1. In this IPER the following documents will be referred to:

D1: WO-97/13266

D2: US-6106659

D3: JP-62077479

2. Clarity (Art.6 PCT)

- 2.1 In present claims 1, 3, 16 and 18 the term "truncated" is not clear. On page 28, line 12-15 it is described that the term "truncated" is taken to include "limited in amplitude to a maximum and/or minimum voltage" and/or to include "narrowed in pulse width". The first definition includes any (physical) waveform, the second definition is not clear (narrowed with regard whereto?). The wording "waveform with a substantially flat profile at its extreme value or values" on page 28 is used only to describe an example of a truncated waveform ("typically leading to") but not to define the term "truncated". Based on said definition on page 28, in the following any waveform is considered to be truncated (i.e. limited in amplitude).

Present claims 6-8 are not clearly defined, since the equations E1-E3 (and the contained parameters) are not defined in the respective claims.

The method of present claim 19 is solely defined by reference to the description and drawings. Claim 19 does thereby not meet Rule 6.2a PCT and cannot be examined with regard to Art.33 PCT.

In present claims 1-3 the term "the applied voltage" is understood as "... the voltage applied across a gas to generate the plasma".

In present claims 10 (line 15) and 17 (line 21) it is understood that the term "preceding" means 'preceding the maximum magnitude of the voltage'.

In claims 11-14 it is not clear whether the term "portion of time" only refers to a period of time or also to a point of time. In the following the latter is assumed.

- 2.2 On page 23 the parameter "N" is not defined. The definition of N is however necessary for the definition of $V(t)$.

The values $x_1=0$ and $x_1=\pi/2$ have to be excluded in the equations given on page 19, 22, 28 and 29, since for these values the waveform $V(t)$ is not sinusoidal shaped with

its peak levelled to a flat top.

In table 1 the units " cm^6/s " appear to be an obvious error, correctly being expressed by " cm^3/s ".

The unit " Td " expressed on page 12 is not expressed in SI units (international practice, Rule 10d PCT).

The expressions " $\dots\text{mA}/\pi^2$ " and " $\dots\text{mA}/\pi^3$ " on pages 15, line 12, 17 and on page 16, line 2 appear to be an obvious error, correctly being expressed by " $\dots\text{mA}/\pi(2\text{cm})^2$ " and " $\dots\text{mA}/\pi(3\text{cm})^2$ ".

3. Novelty (Art. 33.2 PCT)

- 3.1 D1 (cf. page 5, line 5-10; page 24, line 4-21, Fig.8) discloses a method of generating a gas plasma between two electrodes, by applying a repetitive, from its peak value asymmetrically decaying voltage pulse to the electrodes.

The subject matter of present claim 2 is therefore not new with regard to D1 (Art. 33.2 PCT).

- 3.2 The voltage waveform of D1 is truncated in the sense of the definition on page 28, line 12-15 (cf. item 2.1 above).

The subject matter of present claims 1 and 3 is therefore not new with regard to D1 (Art. 33.2 PCT).

The subject matter of present dependent claim 4 is apparently also not new with regard to D1 (cf. above citations).

- 3.3 D1 (cf. citations above, abstract and Figs.10a-c) discloses a method of generating a non-thermal atmospheric gas plasma, wherein a voltage is applied across a gas. The waveform of the applied voltage (cf. Fig.10a-c) is a truncated sinusoid (in the sense of the definition on page 28, line 12-15, i.e. limited in amplitude). It appears that also the waveform shown in Fig.8a,b can be considered as truncated sinusoid.

The subject matter of present claims 16 is therefore not new with regard to D1 (Art. 33.2 PCT).

- 3.4 D2 (cf. col.8, line 53 - col.9, line 24; col.17, line 1-21; Fig.10) discloses a method of generating a gas plasma, by applying a voltage across the gas, wherein the waveform of the voltage decays asymmetrically from its peak value. The voltage waveform comprises a plateau (cf. col.17, line 11) and is thereby truncated at the maximum.

The subject matter of present claims 1-3 is therefore not new with respect to D2 (Art. 33.2 PCT).

The subject matter of present dependent claims 4 and 5 (const. voltage over the plateau) is apparently also not new with regard to D2 (cf. Fig.10).

- 3.5 D2 (cf. citations above, abstract and Fig.11) discloses a method of generating a non-thermal atmospheric (cf. e.g. abstract) gas plasma, wherein a voltage is applied across a gas, the voltage having a waveform which is a truncated sinusoid (cf. Figs.10 and 11).

The subject matter of present claim 16 is therefore not new with regard to D2 (Art. 33.2 PCT).

- 3.6 The waveform of the applied voltage of D2 is periodic and decays asymmetrically from its peak value (as stated above), wherein the peak value is the maximum magnitude of the voltage in each period (of the waveform), and wherein the peak value is closer in time to a preceding maximum in the magnitude of the current (i.e. a current maximum preceding the peak value of the voltage) than to a second following maximum in the magnitude of the current (cf. Fig.10). The waveform follows a sinusoidal function in a portion preceding the maximum magnitude of the voltage and is reduced below said sinusoidal function in a portion following the maximum magnitude of the voltage (cf. Fig.10).

The subject matter of present claims 10 and 17 is therefore not new with regard to D2 (Art. 33.2 PCT).

- 3.7 The subject matter of dependent claims 11, 13-15 and 18 is apparently also not new

with regard to D2 (cf. Fig.10).

- 3.8 D3 (cf. abstract and Figs.2,3) discloses a method of generating a gas plasma between two electrodes, by applying a square wave high-frequency voltage via a capacitor for impedance matching to the electrodes. The voltage waveform is thereby truncated (cf. Figs. 2,3). The voltage waveform applied to the electrodes also decays asymmetrically from its peak value (cf. Fig, 2b, 3b).

The subject matter of present claims 1-3 is therefore not new with respect to D3 (Art. 33.2 PCT).

The subject matter of present dependent claims 4 and 5 is apparently also not new with regard to D3 (cf. Figs.2,3).

- 3.9. The subject matter of present claims 9 and 12 appears to be new.

The subject matter of present claims 6-9, when the respective equations (and parameter definitions) described in the description are included, appears also to be new.

4. Inventive step (Art. 33.3 PCT)

The subject matter of present claims 9 and 12 appears to be inventive.

The subject matter of present claims 6-9, when the respective equations (and parameter definitions) described in the description are included, appears also to be inventive.

5. Industrial applicability (Art. 33.4 PCT)

The subject matter of the present set of claims 1-18 appears to be industrially applicable (Art. 33.4 PCT).

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